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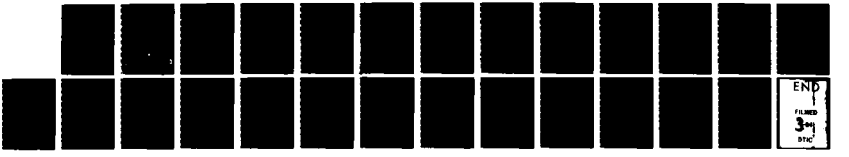

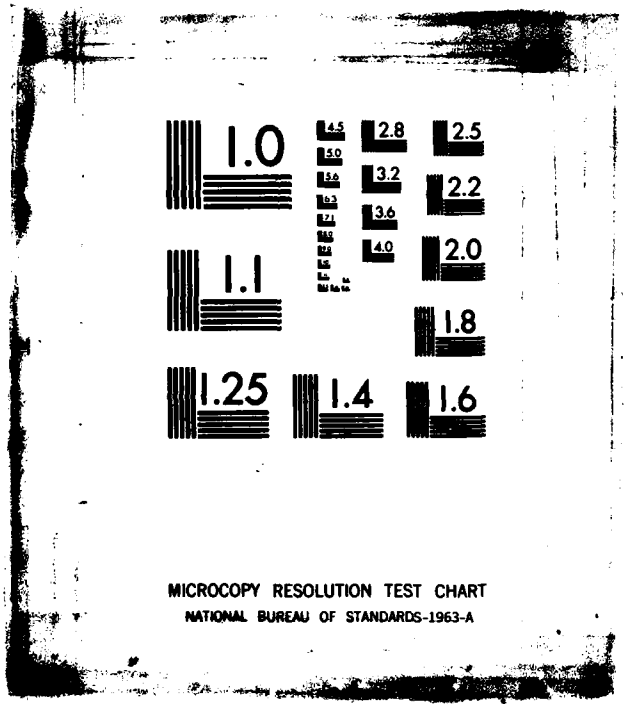

NRL Memorandum Report 5250

Linear-Force Actuators for Use on Shipboard Weapons and Cargo Elevators

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Marine Technology Division

January 9, 1984

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) Reports of hydraulic problems in weapons elevator systems prompted a low-level study. Major areas of concern are: hydraulic fluid leakage; contamination of hydraulic fluid; maintenance and repair. Findings and recommendations are discussed in this report.	

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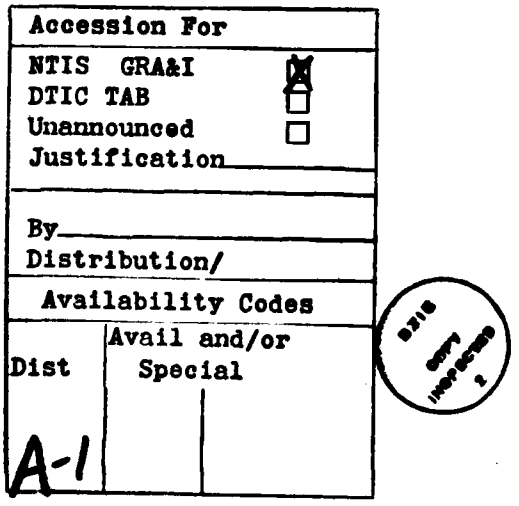

LINEAR-FORCE ACTUATORS FOR USE ON SHIPBOARD WEAPONS AND CARGO ELEVATORS

1. INTRODUCTION

Naval shipboard cargo and weapons elevators use hydraulic linear actuators in a variety of control functions. These hydraulic actuators are used for opening and closing hatches and doors, for dogging and undogging hatches and doors, for latching hatches and for elevating certain platforms. The hydraulic systems operating these actuators and the actuators themselves have been a source of maintenance problems. Minute scratches on the actuator rod and corrosion caused by the high corrosive environment of Aqueous Film Forming Foam (AFFF) mixed with salt water have been responsible for leakage problems. The ethylene glycol mixture used in warships for hydraulic fluid has frequently caused the shorting or overheating and burning of electrical solenoids used in conjunction with automatic hydraulic valves. When actuators or valves are replaced because of wear or other malfunction, the need to open the hydraulic system contributes to the possibility of contaminating the hydraulic fluid. Large hydraulic systems associated with weapons elevators can sometimes take a considerable number of days to bleed free of contaminating material.

This report outlines efforts by NRL to find more reliable components, advanced techniques or other methods to improve hydraulic reliability for elevator systems. These efforts were restricted to the accumulation of information and did not include designs and models of potentially superior hydraulic components.

2. SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

A well-designed and executed conventional hydraulic system represents the best current approach for dogging/undogging, latching/unlatching or opening/closing of hatches and doors. Such systems, however, should be designed by individuals with one standard system concept in mind. A single coordinated group with well-defined design concepts should be established and be responsible for hydraulic circuit design, component selection and installation supervision.

Manuscript approved October 21, 1983.

Electronic test instrumentation should be considered for purchase or development to monitor the condition of elevator hydraulic systems and predict hydraulic system problems before they occur.

3. GENERAL CONCLUSIONS AND RECOMMENDATIONS

It is evident that many short-term and long-term actions can be taken to provide a hydraulic system with increased reliability and at the same time require lower maintainability skills. Note that these recommendations are the result of a very abbreviated study which did not adequately address the total number of elevators in operation in the fleet:

a) Although much useful information was obtained from visits to the aircraft carrier USS INDEPENDENCE (CV62), USS L. Y. SPEAR (AS36) and the USS EMORY S. LAND (AS39), the number of service groups interviewed was too small a sample for a reliable assessment of service and maintenance expertise.

b) Most contacts stated that they liked the current hydraulic system and had no major problems with maintenance. Hydraulic system problems were considered to be due primarily to human error rather than to design or equipment faults. It should be noted here that good engineering practices can reduce the incidence of human error.

c) Installation practices should be improved. It was noted that some practices were incorrect and would lead to early failures, while others exposed the system to accidental damage. Closer supervision of contractors is indicated.

d) Minor low cost improvements should be authorized to increase reliability and decrease down-time. Examples are: piston rod covers in areas exposed to dirt and salt water, filters in hydraulic lines feeding control valves, AC voltage regulators to prevent overheating of solenoid coils, shut-off valves as diagnostic and repair aids, provide better access to components located in the elevator trunk, etc.

e) Portable or permanent electronic monitoring equipment should be considered for purchase or development to check the condition of

hydraulic fluid and components. This would include checks on viscosity, water content, PH, pressure gradients, flow rates, shut off rates, timing, etc. Such monitoring could be easily attainable with current technology. The reliability of a simple monitoring system would not affect the overall reliability of the hydraulic system; however, a properly operating monitoring system could predict problem areas before failure.

f) Timers and/or counters should be installed to monitor actual operational events or on-time.

g) A "Standard Elevator Hydraulic Control System Specification" should be developed similar to the "Standard Elevator Electronic Control System Specification". A responsible group should check all new procurement vendor drawings, specifications, components and installations to this standard.

h) Develop a Military Standard and Preferred Standard Component Specification for hydraulic components and assemblies.

i) It is recommended that the basic current elevator control system is retained and that no new technology is introduced. It is also suggested that in small elevator systems where only a single door is dogged and undogged by a hydraulic cylinder, the use of an electro-mechanical cylinder be considered.

4. STUDY APPROACH

In conjunction with elevator reliability and maintainability studies, a separate low-level investigation was authorized by NAVSEA in November 1982 to investigate reports of hydraulic actuator problems. In conformance with this authorization the following actions were taken.

a) Vendor Contacts:

Vendors were contacted to study currently available products. It was hoped that improved products and new techniques would resolve maintenance problems experienced by the Navy.

b) Catalog Search:

Available catalogs were reviewed for improved actuators and new methods for actuator application.

c) Patent Search:

A patent search was requested to reveal the latest technological developments.

d) On-site Inspection:

Several ships were visited to study shipboard installations.

e) Personal Contacts:

Repair and maintenance personnel were contacted and questioned about specific maintenance and design problems.

5. VENDOR CONTACTS

A Sources Sought Notice was placed in the Commerce Business Daily which called for heavy-duty linear actuators under automatic control for use on U.S. Navy ships. These actuators must either be all-electric or electric-hydraulic in action. Technical data and other descriptive literature was solicited.

Eleven companies responded:

a) Trident Valve Company
b) Electro-mechanical Division of McDonnell Douglas
c) Teleflex
d) Hoover Electric
e) Saginaw Steering Gear Division of General Motors Corporation
f) Air-dro
g) General Automatic Corporation
h) RAM Engineering
i) Rockwood Systems
j) CEF Industries
k) General Oceanics

Sufficient information was received to show that hydraulic actuators can be replaced by electro/mechanical or electro/hydraulic actuators. A standard line of such actuators does not exist and actuators must be custom designed

for specific applications. A linear actuator and drive motor can be combined in a single package, or the motor can be located remotely in a more convenient location.

Summaries of individual replies to the "Sources Sought Notice" are listed below.

Electro-mechanical actuators might be an attractive alternative in small elevator systems where only one or two doors are latched by hydraulic means.

An example of such an installation might be the 16,000 lb. #5 elevator on the auxiliary USS EMORY S. LAND (AS39). This elevator has only one door which is hydraulically opened and closed. An electro-mechanical system could be developed for this door and performance data collected and evaluated for use on other installations.

Trident Valve Company, 329 Center Avenue, Mamaroneck, NY 105403, Donald E. Keogh, Sales Manager

This company has developed electro-hydraulic units to open and close valves. These units utilize an electric motor, driving a hydraulic pump, which in turn, drives a vane actuator which is directly coupled to the driven unit. These units produce operate 280° rotation as standard. On the auto-lock units an electro-mechanical brake is furnished so that when the unit stops at any position, its brake locks automatically, preventing any drift. The auto-lock units are also capable of variable opening and closing speeds.

In their cover letter, Trident expressed an interest in developing actuators suitable to Navy requirements.

Trident actuators as described in the literature have a rotary output and are not directly applicable as linear actuators. However the rotary output can be coupled to a lead screw and nut arrangement and can be made into a linear actuator.

Due to the large number of electrical, hydraulic and mechanical parts, the reliability of such actuators should be carefully considered.

Electro-Mechanical Division McDonnell Douglas Electronics Company
Box 1704, Grand Rapids, Michigan 49501, S. H. Parker, Marketing Manager

This division of McDonnell Douglas produces electro-mechanical actuators to meet specifications of various governmental agencies and civilian customers.

In reply to NRL's request for literature, McDonnell supplied a catalog showing many examples of custom designed actuators with strokes of varying lengths. Units can be built with input sockets and manual hand-cranks in case of an electric outage or a motor failure.

Almost all units are single integrated units, but units can also be made where the motor is located remotely and rotary motion from the motor is delivered to the actuator by rigid shafts and flexible couplings. Actuators for Navy elevator use would have to be custom designed to meet specific application requirements.

Teleflex, 155 South Limerick Road, Limerick, PA 19468

Teleflex produces linear induction motors with no apparent limit to size and thrust. No production actuators, linear motor designs or actual applications were shown or described in their literature and it must be assumed that this type of equipment is strictly custom designed.

Hoover Electric, 2100 South Stoner Avenue, Los Angeles, CA 90025

Hoover Electric, a subsidiary of Teleflex, fabricates electric linear actuators based on a motor driven ball screw arrangement. These units can produce up to 20,000 lbs. of thrust with strokes up to 38".

Hoover produces custom designed actuators which consist of a single electro-mechanical package, or in a configuration where the motor is remotely located and where the rotary motion of the motor is transmitted to the actuator by a flexible cable.

Saginaw Steering Gear Division of the General Motors Corporation
Saginaw, Michigan 48605

This company produces electric motor driven, linear, programmable positioning actuators with strokes up to 36" and thrusts of 1,500 lbs. A sketch of their standard production line actuator is shown in Fig. 1 below.

These actuators are commercial units sold through local distributors and have the following features:

a) Efficient ball screw actuation.
b) All-steel load support members.
c) Compression or tension loads.
d) Electrical or manual operation.
e) Integral brake.
f) Lubricated for life.
g) Weather proof.
h) 30% duty cycle motor ratings.
i) Spur gear reduction.
j) Optional solenoid brake (AC) motors.
k) Motor braking (DC motors).
l) 3000 pound static capacity.
m) Internal stops activate slip clutch at each end of full stroke (external stops are not to be used).
n) Multiple manual units easily synchronized.
o) Customized stroke to 36 inches.
p) Trunnion-clevis mounting.

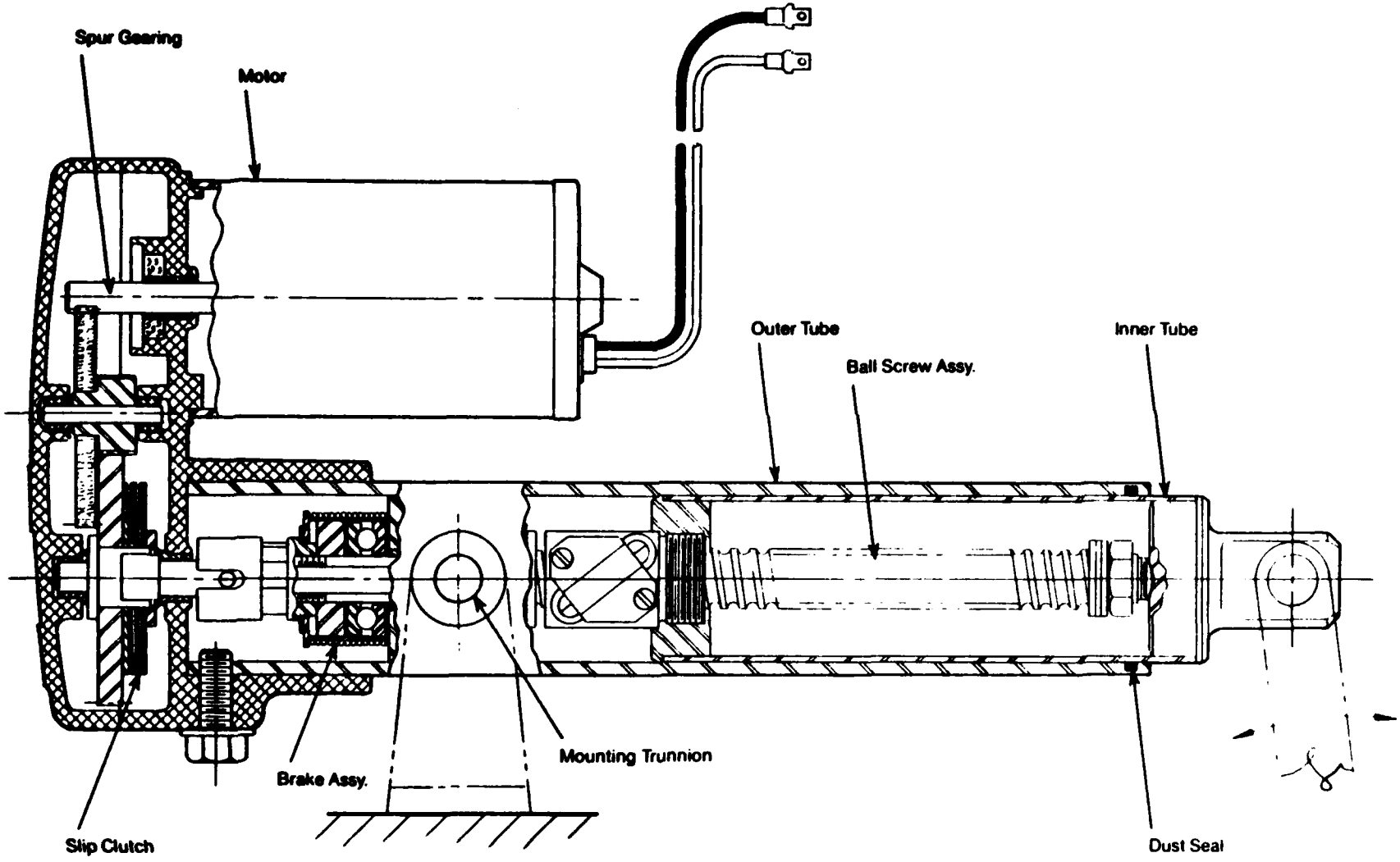

Fig. 1 — Electrical linear actuator

Air-dro, Decatur, Alabama.

Air-dro manufactures hydraulic and pneumatic cylinders, actuators and boosters. Work has been performed for NASA, U.S. Army, U.S. Coast Guard, U.S. Navy, U.S. Air Force and several prime defense contractors. Air-dro's quality assurance system is in accordance with Military Specification MIL-Q-9858A entitled "Quality Program Requirements". Their inspection system is maintained in accordance with specification MIL-I-45208A entitled "Inspection System Requirements".

Air-dro did not comply with NRL's request for technical data and other descriptive literature for all-electric or electric-hydraulic actuators.

General Automatic Corporation, 70 Liberty Street, Metuchen, NJ 08840

General Automatic Corporation did not supply enough information for evaluation of their product line. They manufacture a variety of electromagnetic actuators, but from the limited amount of data furnished it seems that the equipment did not meet requirements for dogging and undogging as well as opening and closing of hatches and doors in Navy elevator applications.

However, the company did request to be considered for qualification and/or procurements of actuators. A procurement contract would have to include a development contract.

RAM Engineering, 64 North 800 East, St. George, Utah 84770
Doug McCann, Sales Manager.

RAM Engineering manufactures solenoid actuators. RAM did not supply any technical data or descriptive literature, but requested a bid package.

Rockwood Systems Corporation, 8350 North Central Expressway, Dallas, Texas 75206, Catherine A. Furey

Rockwood Systems Corporation supplied no data, but requested a bid package.

CEF Industries, 506 Highway 27 North, Haines City, Florida 33844
Robert J. Becker, Applications Engineer

CEF Industries designs, develops, qualifies and manufactures electronic and electro-mechanical flight sensitive systems for aircraft. This includes the development of black boxes as well as mechanical and electro-mechanical actuators.

Linear actuators are based on ball screw arrangements which are driven by hydraulic or electric motors. All products have been developed for use in aircraft and are not directly applicable to shipboard use. A development contract would be required for actuators in elevator applications.

The actuators which were shown in CEF literature consisted of drive motors located remotely from the actuators. Rigid shafts and flexible cables connect the drive motors to the actuators.

General Oceanics, Coral Gables, Florida

The General Oceanic catalog did not list any actuators.

6. CATALOG SEARCH

Product lines from approximately 45 manufacturers were reviewed from available catalogs and bulletins. (Not including manufacturers under the heading "Vendor Contacts".)

The equipment reviewed was primarily pneumatic, hydraulic, or pneumatic to hydraulic. It included pneumatic and hydraulic cylinders, valves, pumps, motors, seals, filters, controls, electronic modules, servo-systems, power plants, etc. A description of companies and company-product-lines exceeds the scope of this report.

By proper choice of components and adherence to recommendations for proper usage, it should be possible to assemble a reliable hydraulic system of any size or scope. Due to the large number of manufacturers and available components, a responsible group or department with appropriate authority should review all hydraulic elevator systems and components to limit the proliferation of parts, assure good engineering practice and establish an approved vendor list.

Some manufacturers comments and recommendations are listed below.

1) Use shields or rubber boots to protect cylinder rods from dirt.
2) Eliminate side loads on hydraulic pistons.
3) Water glycol hydraulic fluids require different seal materials than hydro-carbon based hydraulic fluids or phosphate ester fluids.
4) Water based hydraulic fluids have less lubricating properties than the standard petroleum oils. This affects component designs.
5) Metal parts should be treated to protect against rust if a water based hydraulic fluid is used.
6) Seals should be designed for specific temperature ranges. For every 20°F rise in temperature, seal life is halved.
7) Use of oil filters is recommended.
8) Electrically operated hydraulic valves should be designed to conform to the voltage fluctuations generally encountered in industrial applications. (Ship power often exceeds standard industrial limits.)

It was found that in shipboard elevator installations manufacturer's recommendations for the design and maintenance of hydraulic systems are not always followed.

7. PATENT SEARCH

As part of the investigative portion of this study, a request for a patent search was submitted on 30 November 1982 to Dr. Ellis, Patent Counsel, NRL Code 2004. The search was to include linear actuators which are electro-mechanical or electro-hydraulic in nature.

The search was conducted in class 254/93 (implements or apparatus for applying pushing or pulling force/fluid pressure); class 187/17 (elevators/motor mechanisms); and class 251/129 (valve and valve actuation/electrical actuators).

It was found that actuators for moving heavy loads were generally hydraulic. Some patents were found with an appended electrical apparatus for generating hydraulic pressure. In most applications electrical actuators were utilized to adjust valves controlling the flow of the hydraulic motive fluid.

Patents considered relevant by the patent council to the subject search are listed below.

1) 3,801,151 Title "Double-Acting Lift Cylinder with Integral Velocity Fuses".
2) 3,918,683 Title "Electro-Hydraulic Jack".
3) 4,037,821 Title "Telescoping Retractor".
4) 4,244,627 Title "Lift Cylinder Assembly".
5) 4,076,215 Title "Electrohydraulic Drawing Apparatus, Particularly a Hoist".

The patent search did not reveal any methods, techniques, practices or arrangement of components which were thought to be useful in reducing maintenance and repair problems in shipboard elevator systems.

Patent #4,244,627 might possibly be of importance if it can be shown that the seal described reduces the penetration of AFFF and consequent mixing with hydraulic fluid.

A listing of patents and a brief description follows.

1) Patent # 3,801,151

In installations where a hydraulic lift cylinder is used to raise or lower a load, it is the practice to employ a velocity fuse to

prevent uncontrolled free-fall of the load in the event of a failure such as a leak in the hydraulic fluid system which operates the cylinder. In such a system it was the practice that the velocity fuse was structurally independent of the lift cylinder and was physically mounted in the hydraulic fluid line leading to the appropriate end of the cylinder. This patent discloses a single-acting hydraulic lift cylinder with a single velocity fuse mounted integral with the lift cylinder to prevent an uncontrolled free-fall if the hydraulic hose connecting the cylinder to the fuse develops a leak.

This patent disclosure is not relevant to the context of this study report.

2) Patent #3,918,683

This patent describes a jack intended for use with automobiles including a compact easily positioned jack assembly and means for electrically operating the hydraulic power unit. The jack assembly has a head support that will adapt to be used with a bumper or that will provide a ram head to be used under axles and the like. The novelty is the shape of the head of the actuator which is shaped specifically for the lifting of automobiles.

The packaging concept may be considered to be novel, however this patent does not show any novel or useful features in linear actuators for elevator applications.

3) Patent #4,037,821

This patent describes a telescoping actuator with specific application for the extraction of umbilical connectors of missiles prior to launch. The piston is actuated by an "electro-explosive power cartridge".

Features of this invention do not appear to be useful for Navy elevator applications.

4) Patent #4,244,627

This patent describes a novel shaft seal and guide bushing which are supported in a manner to eliminate eccentricity stack-up. This patent disclosure may have some relevancy to this study.

5) Patent #4,076,215

This patent describes an electrohydraulic drawing or hoisting apparatus for the pulling or lifting and lowering of loads in which an electro-hydraulic power unit is rigidly connected to one end of a cylinder piston unit.

A control handle is connected to the hydraulic control unit so that the directions of displacement of the handle and the resulting motion of the load lifting member coincide substantially. The speed of the piston in both directions is continuously variable as a function of the displacement of the control handle.

The major novelty here lies in the handle control unit.

8. ON-SITE INSPECTION

During the time period of 9 May to 12 May 1983 the author attended the "Fleet Elevator Workshop" in Norfolk, VA sponsored by the Naval Sea Systems Command (NAVSEA). Following the workshop on 13 May 1983, visits were made to the aircraft carrier USS INDEPENDENCE (CV62), the USS EMORY S. LAND (AS39) and the USS L. Y. SPEAR (AS36) to view typical elevator installations from the total inventory of approximately 600 elevators. This was an insufficient group sample, but some interesting observations can be made

USS INDEPENDENCE (CV62)

a) Hydraulic cylinders which close horizontal sliding doors are rigidly supported at both ends of the cylinder. This causes excessive side loads on the shaft and shaft seals.
b) Rigid pipe is used to supply hydraulic fluid to these cylinders.
c) Piping to these cylinders is arranged so that it protrudes into the work area and is subject to accidental damage. Rotation of the cylinder by 90° would eliminate this condition.
d) The deck hatch dogging actuator cylinders are mounted rigidly at both ends.

e) Hydraulic cylinders in the elevator trunk are installed in such a manner that hydraulic hoses protrude into the trunk area and are subject to damage from falling objects. A 90° rotation of the cylinder will eliminate this potential hazzard.

f) Rod covers should be installed over piston rods for protection from dirt, salt water, paint, etc.

g) Hydraulic actuators located in the elevator trunk are difficult to inspect and service due to their location. Better access to these components should be provided, such as ladders, walkways, etc.

USS EMORY S. LAND (AS39) AND USS L. Y. SPEAR (AS36)

These ships use simple elevator systems and most access doors are secured manually.

9. PERSONAL CONTACTS

Simultaneously with the inspection trip to the aircraft carrier USS INDEPENDENCE, the USS L.Y. SPEAR and the USS EMORY S. LAND, arrangements were made to meet with individuals directly involved in elevator and shipboard hydraulic maintenance and repair. The result of these meetings was unexpected since they revealed fewer problems than had been anticipated. It should be noted that the repair crews on these three ships were well trained and qualified to maintain the subject systems and that this may or may not be a common situation on other ships. Additional interviews would be required in order to obtain a more representative picture of repair and maintenance readiness.

Some of the crew members interviewed are listed below.

Aircraft Carrier USS INDEPENDENCE	EM3 Cox
	EN1 Pat Ryals
AS39 - EMORY S. LAND	EM2 Fox
	EM Chief Manuel
	Gregg McCollum
AS36 - L. Y. SPEAR	EM1 Sant. Deguzman
	EM1 S. Lead

A set list of questions was asked at each meeting both to obtain specific answers and also to stimulate an open discussion on hydraulic problems. A copy of questions and answers for the USS INDEPENDENCE are given in Table 1.

Other DoD contacts:

Donald Morris	NAVSEA
J. Milton Oakley	NAVSEACENLANT
Joseph Mislan	NAVSSES
David Hughs	PSNSY
Geoffrey O. Thomas	NRL
Perry Alers	NRL

Comments from these sources are summarized as follows.

In 1975/6 the HECO and Flodyne hydraulic power plants were removed from elevator systems and were replaced with a more reliable hydraulic unit. This, plus other changes has improved system reliability and maintainability. A few problem areas, however, remain. Hydraulic seals deteriorate and cause leaks, and broken seal material contaminates the hydraulic fluid. Pieces of material from seals, gaskets and "O" rings are caught in hydraulic valves and interfere with the operation. Hydraulic leaks are also responsible for shorting and overheating of the electrical coils in control valves.

Hydraulic logic circuits have not yet been "standardized" and may vary from ship to ship; therefore repairs are difficult and time consuming until the repair crew has been re-trained and has become familiar with the ship's installation. Installations frequently use hydraulic components from different manufacturers. This results in a proliferation of stocked repair parts which compounds the problem.

Experimentation with a new technology for actuators (i.e., electro-mechanical, etc.) did not find much support. Logic circuit and component standardization was favored. This can be implemented in two steps:

a) Develop a standard hydraulic control specification similar to the standard elevator electronic control specification.

b) Develop a Military Standard or Specification for hydraulic components similar to current practice for electronic components.

Under such a system all manufacturers can share in supplying hydraulic components which are directly replaceable without modification.

Table 1

USS INDEPENDENCE (CV62)

ELECTRICALLY OPERATED HYDRAULIC VALVES

	QUESTIONS		ANSWERS
1.	Is there a problem?		Yes
2.	Hydraulic valves need repair or replacement?		
	a. Almost never		
	b. Seldom		
	c. Average		X
	d. Often		
	e. Very Often		
3.	Repairs are usually		
	a. Easy	Explain	Replace "O" Rings and clean
	b. Difficult	Explain	
	c. Replace the whole unit	Explain	
4.	Type of problem, % of each problem		
	a. Electrical connector does not make electrical contact. Clean connector.		No problems.
	b. Solenoid burns out.		No problems. Problems exist with the no load start relief valve only.
	c. Dirt in orifice.		No dirt; fluid becomes viscous; then water or new fluid must be added.
5.	d. Spool does not shift.		Yes; fluid dries out and becomes gummy and hard.
	e. External oil leak.		No
	f. Internal oil leak, unit does not shut fully off.		Because of gumming, hydraulic fluid leaks, then water evaporates and the residue becomes thick and sticky.
	g. Unit does not fully turn on.		No
	h. Other		Wrong replacement coil.

Table 1 (con't.)

USS INDEPENDENCE (CV62)

ELECTRICALLY OPERATED HYDRAULIC VALVES

	QUESTIONS	ANSWERS
6.	Can valve or valve parts be identified?	Yes. No problem.
7.	Do labels fall off or come loose?	Yes, if hydraulic fluid gets on them.
8.	Are repair parts available?	No; lead time is too long.
9.	Are repair instructions available?	Yes
10.	Is application information available?	Yes
11.	What manufacturers are good?	All manufacturers are good.
12.	What manufacturers are bad?	None
13.	Suggestions, recommendations.	

The following suggestions, recommendations or comments were made by various individuals.

a. When the hydraulic system is drained, some fluid remains in valves and other areas. This fluid then loses water and becomes sticky and gummy.
b. Hydraulic fluid was changed in 1978. The new fluid did not mix with the remains of the old fluid and produced a gummy residue which plugged up the valves. All valves had to be cleaned or replaced and the system did not operate reliably until early 1983.
c. Hydraulic actuators and the whole hydraulic system is OK. Problems are caused by human error.
d. There are not enough shut off valves. This makes it difficult to isolate a problem or to replace components. In one instance the hydraulic fluid drained out of one of the accumulators when a solenoid had to be replaced.
e. Various contacts liked the hydraulic system. It is easy to service and trouble-shoot. They do not want a different system.

Table 1 (con't.)

USS INDEPENDENCE (CV62)

HYDRAULIC HOSES, PIPES

	QUESTIONS	ANSWERS
1.	Is there a problem?	Hoses - YES. Pipes - NO.
2.	Type of problem, % of each problem	
	a. Leaks	Yes; hose breaks down. A bubble forms on the outside of the hose and it starts to leak.
	b. Breaks	No.
	c. Too long	They order long lengths of hose and then cut it to the correct length.
	d. Too short	
	e. Hose rubs against surface until a hole or leak develops	Yes; but this is a human error; bad installation.
3.	Can parts be identified?	No
4.	Are repair parts available?	No
5.	Which manufacturers are good?	N/A
6.	Which manufacturers are bad?	N/A
7.	Suggestions, recommendations.	

Table 1 (con't.)

USS INDEPENDENCE (CV62)

HYDRAULIC ACTUATORS

	QUESTIONS		ANSWERS
1.	Is there a problem with hydraulic actuators?		No
2.	Hydraulic actuators need repair or replacement		
	a. Almost never		X
	b. Seldom		
	c. Average		
	d. Often		
	e. Very Often		
3.	Repairs are generally		
	a. Easy	Explain	Usually "O" Rings
	b. Difficult	Explain	
	c. Replace the whole unit	Explain	
4.	Type of problem, % of each problem,		
	a. Breaks, cracks		No
	b. Shaft bends, other parts bend or distort		Only the hatch latch cylinder
	c. Dirt		No
	d. Rust		No
	e. Shaft seal wears		Very seldom
	f. Oil leaks		No; leaks occur in valves and at pipe connections.
	g. Piston binds		No.
	h. Piston will not move to end of stroke		No.
	i. Other		
5.	Can actuator and associated parts be easily identified?		No problem.
6.	Are repair parts available?		No.

Table 1 (con't.)

USS INDEPENDENCE (CV62)

HYDRAULIC ACTUATORS
(continued)

	QUESTIONS	ANSWERS
7.	Repair parts don't fit?	No problem.
8.	Are repair instructions available?	Yes.
9.	What manufacturers are good?	Parker Hannifin.
10.	What manufacturers are bad?	None.
11.	Should parts be re-designed, improved or replaced with a different vendor?	
	a. Yes	
	b. No	X
	c. Urgent	
	d. At some future time	

Comments made during the discussion:

a) When a system is drained, teflon and neoprene seals become dry and deteriorate and then break up. Pieces then will get into valves and jam up those valves after the system is re-filled.
b) The complete system is drained and refilled about once a year.

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